

SECTION 501 - CONCRETE

Delete Sec 501 and substitute the following:

501.1 Description. Concrete shall consist of a mixture of cement, fine aggregate, coarse aggregate and water combined in the proportions specified for the various classes. Admixtures for the purpose of entraining air, retarding or accelerating the set, tinting and other purposes may be added as specifically required or permitted.

501.2 Material.

501.2.1 All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Coarse Aggregate ¹	1005.1
Fine Aggregate ¹	1005.2
Ground Granulated Blast Furnace Slag	1017
Fly Ash	1018
Cement	1019
Concrete Admixture	1054
Concrete Tinting Material	1056
Water	1070

1. Regardless of the gradation of the coarse and fine aggregates used in concrete for pavement or base, they shall meet the quality requirements of coarse and fine aggregate for concrete pavement.

501.2.2 Mix Design. The proportions of cement, fine aggregate and coarse aggregate for concrete shall be approved by the engineer within the applicable limits of the specifications for the class of concrete specified in the contract. For PCCP mixes, the contractor may submit an optimized mix design for approval or accept a standard mix designed by the engineer. Optimized refers to aggregate gradations which produce lower water demands as well as improved workability and finishing characteristics. When an optimized gradation is used, the gradation requirements of 1005.1 shall not apply, however, 100 percent of each fraction shall pass the 2 inch (50 mm) sieve, or the 1/2 inch (12.5 mm) sieve when [Sec 1005](#) Gradation F is required, and not more than 2.5 percent shall pass the No. 200 (75 µm) sieve. When an optimized mix is submitted, the target gradation and allowable gradation range of each fraction shall be included. The contractor may be required to submit representative samples of each ingredient to Project Operations for laboratory testing. The engineer assumes no responsibility for the volume of concrete produced or furnished for the work.

501.2.2.1 The proportions for any mixture of material obtained from established and approved commercial sources may be obtained by the contractor from the engineer upon request. If the contractor desires to ascertain the mix for a certain combination of aggregates obtained from commercial sources before construction work starts, the engineer shall be advised in writing of the specific source of material which the contractor desires to use, and the engineer will supply the contractor with the mix for each combination of coarse and fine aggregates for which a specific request is made. If mix design information is desired for bidding, requests for such information may be made to the District Engineer at the District Office or Project Operations. The contractor shall make the request as far in advance of the bid opening as possible to allow the engineer sufficient time to furnish a reply. The mix set by the engineer will be based upon

the material designated by the contractor as intended for use in the work and, if sources of supply are changed, the mix may be revised if necessary.

501.2.2.2 For simplicity of design, the various fine aggregates are grouped into four classes, and a minimum and maximum cement factor has been established for each class. The cement factor for the individual job may vary within the maximum and minimum limits, depending upon the gradation of the coarse aggregate, the quantity of mixing water used, the quantity of entrained air when air-entrained concrete is specified and upon changes in proportions which may be necessary to produce satisfactory workability, strength or entrained air content.

501.2.2.3 The cement factor or the quantity of cement used in any cubic yard (cubic meter) of concrete shall be the cement content in sacks per cubic yard (kilograms per cubic meter) of concrete as determined from a summation of the absolute volumes of all the ingredients and, when air-entrained concrete is specified, the volume of air. The cement requirements in sacks per cubic yard (kilograms per cubic meter) of concrete for the various classes of sand are as follows:

Cement Requirements ^{1,2}												
ENGLISH												
Class of Sand	Class A-1 Concrete		Class B Concrete		Class B-1 Concrete		Class B-2 Concrete		Pavement Concrete		Seal Concrete	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
A	6.40	8.00	5.60	6.00	6.50	7.00	7.50	8.00	6.00	6.40	7.00	8.00
B	6.80	8.00	6.00	6.40	6.80	7.20	7.80	8.20	6.20	6.60	7.40	8.00
C	----	----	6.20	6.60	7.00	7.40	8.00	8.40	6.40	6.80	7.60	8.00
D	----	----	6.60	7.00	7.40	7.80	8.40	8.80	6.80	7.20	7.80	8.00
METRIC												
Class of Sand	Class A-1 Concrete		Class B Concrete		Class B-1 Concrete		Class B-2 Concrete		Pavement Concrete		Seal Concrete	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
A	360	450	310	330	360	390	420	450	330	360	390	450
B	380	450	330	360	380	400	430	460	350	370	410	450
C	----	----	350	370	390	410	450	470	360	380	420	450
D	----	----	370	390	410	430	470	490	380	400	430	450

1. When coarse aggregate, Gradation F in accordance with [Sec 1005.1.2.5](#) is used, the cement requirements shall be increased 0.50 sacks per cubic yard (30 kg/m³) of concrete. When used, Type IP, I(PM), IS or I(SM) cement shall be substituted on a pound for pound (kilogram for kilogram) basis for Type I or Type II cement and adjustment in design mix proportions will be required to correct the volume yield of the mixture.

2. The contractor may submit an optimized mix design for pavement concrete which has a maximum 0.50 sacks per cubic yard (30 kg/m³) reduction in cement from that as shown in the tables. If the contractor chooses this option, the mixture is subject to review, laboratory testing and approval by the engineer. All other requirements for cement factor shall apply.

Class A sand shall include all sand, except manufactured sand, weighing 109 pounds per cubic foot (having a mass of 1740 kg/m³) or more.

Class B sand shall include all chert, river and Crowley Ridge sand weighing from 106 pounds to 108 pounds inclusive per cubic foot (having a mass of 1610 kg/m³ to 1730 kg/m³ inclusive), or glacial sand weighing 108 pounds or less per cubic foot (having a mass of 1730 kg/m³ or less).

Class C sand shall include all chert, river and Crowley Ridge sand weighing from 101 pounds to 105 pounds inclusive per cubic foot (having a mass of 1610 kg/m³ to 1680 kg/m³ inclusive).

Class D sand shall include all sand weighing 100 pounds or less per cubic foot (having a mass of 1600 kg/m³ or less) and any manufactured sand which is produced by the process of grinding and pulverizing large particles of aggregate, or which contains more than 50 percent of material produced by the reduction of coarser particles. Manufactured sand produced from limestone or dolomite shall not be used in portland cement concrete for driving surfaces such as bridge decks, pavements and shoulders.

The weight per cubic foot (mass per cubic meter) shall be the dry rodded weight per cubic foot (mass per cubic meter) of the aggregate, determined in accordance with AASHTO T 19.

501.2.3 Sampling. Sampling of fresh concrete shall be in accordance with AASHTO T 141, except that for central or truck mixed concrete, the entire sample for slump and air tests and for molding compressive strength specimens may be taken at one time after approximately one cubic yard (cubic meter) of concrete has been discharged, instead of at three or more regular intervals during the discharge of the entire batch. Acceptability of the concrete for slump and air content, and if applicable for strength requirements, will be determined by tests on these samples.

501.2.4 Consistency. The slump of the concrete will be approved by the engineer within the following limits for the respective classes of concrete. The concrete shall be uniform in consistency and contain the minimum quantity of water required to produce the designated slump. The slump and mixing water content of the concrete, when placed in the work, shall not exceed the following limits:

Slump and Mixing Water Requirements			
ENGLISH			
Class of Concrete	Max. Slump In.	Maximum Gallons of Mixing Water Per Sack of Cement	
		Air-Entrained	Non-Air-Entrained
A-1	3 ½	5.25	5.75
B	4	5.75	6.25
B-1	4	5.0	6.0
B-2	2 ½	4.5	----
Pavement	2 ½	5.5	6.0
Seal	8	----	6.0
METRIC			
Class of Concrete	Max. Slump mm	Maximum Kilograms of Mixing Water Per Kilogram of Cement	
		Air-Entrained	Non-Air-Entrained
A-1	90	0.46	0.51
B	100	0.51	0.55
B-1	100	0.44	0.53
B-2	60	0.40	----
Pavement	60	0.50	0.53
Seal	200	----	0.53

501.2.4.1 The slump of B-2 concrete may be increased 1/2 inch (13 mm) to improve workability if permitted by the engineer. The slump of concrete for pavement may be increased to a maximum of 3 1/2 inches (90 mm) if finishing by hand methods is permitted and used, provided the cement content is increased 0.25 sack per cubic yard (15 kg/m³) of concrete above that established for the work in accordance with [Sec 501.2.2.3](#).

501.2.4.2 The slump of concrete mixes will be determined in accordance with AASHTO T 119. The quantity of mixing water in the concrete shall be considered the net quantity after proper allowance has been made for absorption by the aggregates.

501.3 Measurement of Material. The cement and aggregates for concrete shall be measured by weight (mass). The weights (masses) of coarse and fine aggregates to be used will be calculated from the proportions approved by the engineer. Batches which do not contain the proper quantities of material shall be wasted at the contractor's expense.

501.3.1 The weighing (mass determination) and batching equipment shall be designed and maintained in such condition that the material for each batch can be quickly and accurately weighed (made) and shall be operated within a tolerance of plus or minus 0.5 percent for cement and plus or minus 1.0 percent for aggregates. Scales shall be sufficiently free from vibration to permit accurate weighing (mass determination) when the plant is in operation. If, for any reason, equipment previously approved becomes unsatisfactory, it shall be repaired or replaced before proceeding with the work. When using stationary mixers with a rated capacity greater than 16 cubic feet (0.45 m³), storage bins with adequate separate compartments shall be provided for bulk cement, if used, for fine aggregate and for each required size of coarse aggregate. The equipment used for delivery of material to bins shall not permit intermingling of aggregates. Each compartment shall be designed to discharge efficiently and freely into the weighing hopper. Weighing hoppers shall be so constructed that there will be no attachments that might affect the free movement of the weighing mechanism (mass determination). Weighing hoppers shall discharge completely and there shall be no accumulation of tare material. Weighing (Mass determination) and batching equipment shall be supported on a firm foundation. If necessary, the weighing hopper shall be protected against the wind. Scales for weighing (determining the mass of) aggregate or cement may be beam, springless dial or electronic digital weight (mass determination) meter type, and shall be of standard make and design. Scales shall be accurate to within 0.4 percent of the net load applied. The change in load required to change the position of rest of the indicating element or elements of indicating scales an observable amount shall not be greater than 0.1 percent of the nominal scale capacity. Exposed fulcrums, clevises and similar working parts of the scale shall be kept clean. If beam-type scales are used, a separate beam shall be provided for each type of material to be used, and means shall be provided for adjustment of tare. For manually operated plants, provisions shall be made to indicate to the operator that the required load in the weighing hopper is being approached. The device shall indicate at least the last 5 percent of the load weighed (applied) on any beam, except that in no case will this increment be required to be greater than 200 pounds (100 kg). Quantity indicators necessary for batching operations shall be in full view of the operator.

501.3.2 Cement shall be measured by weight (mass) or by sacks of standard weight (mass). If cement is measured by weight (mass), it shall be weighed (determined) on a scale separate from those used for other material. If cement is measured by sacks, no fraction of a sack shall be used unless weighed (unless the mass has been determined).

501.3.3 Mixing water shall be measured by volume or by weight (mass). If measured by weight (mass), scales shall be in accordance with [Sec 501.3.1](#). The device for the measurement shall be readily adjustable, and under all operating conditions shall measure the required quantity within a tolerance of one quart (one liter) or one percent, whichever is greater. The device shall be so arranged that the flow of water is automatically stopped when the required quantity has been delivered. Water measuring devices shall be of adequate capacity to furnish the maximum quantity of mixing water required, and shall be equipped with outside taps and valves to permit their calibration under conditions similar to operating conditions.

501.3.4 Personnel, scales and equipment necessary for calibrating the proportioning devices and for verifying the accuracy of proportions shall be furnished by the contractor and shall be available at the proportioning plant at all times. The equipment shall include standard 50-pound (20 kg) test weights equivalent to 20 percent of the net load capacity of the scales, to the nearest greater 50-pound (20 kg) increment. However, not more than twenty 50-pound (20 kg) weights will be required. All equipment shall be calibrated by the contractor in the presence of and subject to the approval of the engineer. Calibration by an approved commercial scale service may be required in case of large capacity scales of greater than 10,000 pounds (4500 kg) or if scales do not meet calibration tolerances.

501.4 Mixing. The concrete mixer shall be of a type approved by the engineer. A mixer used on structural work involving individual pours of 30 cubic yards (25 m³) or more shall have a manufacturer's guaranteed capacity of not less than 10 cubic feet (0.3 m³), and for smaller pours the mixer shall have a manufacturer's guaranteed capacity of not less than 5 cubic feet (0.25 m³).

501.4.1 The mixer shall produce concrete uniform in color, appearance and distribution of the material throughout the mixture. Variations in the mixed concrete reasonably attributable to worn pickup or throw-over blades will be just cause for inspection of such blades. If such inspection reveals the blades to be worn down more than one inch (25 mm) below the original height of the manufacturer's design, the blades shall be repaired or replaced. A copy of the manufacturer's design, showing dimensions and arrangement of blades, shall be made immediately available to the engineer upon request. The cement, aggregates and not less than 60 percent of the water shall be mixed not less than one minute. The remaining water shall be added within 15 seconds after all other material for the batch are in the mixer. If mixers having multiple compartment drums are used, the time required to transfer material between compartments will be considered mixing time. The speed at which the drum rotates shall be as designated by the manufacturer. If such mixing does not result in uniform and smooth texture concrete, a sufficient number of additional revolutions at the same speed shall be given until a thorough mixing of each batch of concrete is secured. If a mixer having a rated capacity of more than 38 cubic feet (1 m³) per batch is used, the mixing time shall be increased 15 seconds for each additional cubic yard (cubic meter) of capacity, or fraction thereof, except as specifically permitted for central mixers in accordance with [Sec 501.5.4](#). The mixing time shall be measured from the time all cement, aggregates and 60 percent of the water, are in the drum. The volume of concrete mixed in each batch shall not exceed the manufacturer's rated capacity.

501.4.2 The mixer shall be equipped to automatically time the mixing of each batch of concrete. Should the automatic timing device become inoperable, a manual timing device shall be provided to complete the day's operation.

501.5 Central and Truck Mixed Concrete. The following additional requirements shall apply to central and truck mixed concrete.

501.5.1 All central mixers, truck mixers and agitators shall comply with the requirements of these specifications prior to use, and inspections of the equipment will be made periodically during the work. Only equipment found acceptable in every respect and capable of producing uniform results will be permitted.

501.5.2 If the concrete is to be used in bridge construction, the contractor shall furnish and conform to a schedule of delivery which provides that all batches receive essentially the same mixing and agitation. Failure to deliver consistently uniform concrete will be cause for its rejection and the contractor will be required to furnish concrete produced by a stationary mixer on the job site without any adjustment in the contract unit price.

501.5.3 Storage facilities for all material shall be designed to permit the engineer to make necessary inspections prior to the batching operations. The facilities shall also permit identification of approved material at all times and shall be designed to avoid any mixing with, or contaminating by, unapproved material. Coarse and fine aggregate shall be so furnished and handled that variations in the moisture content affecting the uniform consistency of the concrete is avoided. Any aggregate fractions used which vary more than one percentage point from the mean moisture content established near the start of the day's operations on the structure section, when delivered to the weighing hopper during any one pour of concrete, will be subject to rejection. The engineer may permit a change in the mean moisture content, and the moisture content of the aggregate shall then vary not more than one percentage point from the newly established mean. These provisions shall in no way alter the slump and mixing water requirements of the specifications for concrete. The fine aggregate bin or weighing hopper shall be equipped with a moisture sensing device which shall consistently indicate the moisture content within 0.5 percent of the dry weight (mass) of the aggregate. The indicator shall be in such position that it may be readily observed by the operator during batching operations. These requirements for specific limits on moisture variation and for a moisture sensing device are not applicable to pavement concrete.

501.5.4 Central mixed concrete shall be mixed in a stationary mixer in accordance with the requirements specified herein. Except as otherwise permitted in accordance with [Sec 501.5.11](#), it shall be transported to the point of delivery in a truck mixer operating at agitating speed, or in an agitator truck. The mixing time shall be in accordance with [Sec 501.4.1](#) and as necessary to produce concrete which meets uniformity criteria when tested in accordance with Section 10.3 of ASTM C 94 with the following additions and exceptions:

(a) The two samples shall be obtained within an elapsed time of not more than 15 minutes.

(b) The air content, slump and mix proportions of the concrete tested shall be in accordance with [Sec 501](#) for that class of concrete or the uniformity tests shall be invalid.

(c) The use of a one-quarter cubic foot (0.007 m³) measure will be permitted in determination of weight per cubic foot (mass per cubic meter).

(d) Cylinders may be cured in damp sand after the first 48 hours.

(e) The contractor may designate the mixing time for which uniformity tests are to be performed. The mixing time shall not be less than 60 seconds or more than the time determined in accordance with [Sec 501.4.1](#). The maximum mixing time shall not exceed the mixing time established by uniformity tests by more than 60 seconds for air-entrained concrete. The mixed concrete shall meet the uniformity requirements specified above before any concrete may be used for pavement or structures. However, the engineer may allow the use of the test concrete for appropriate incidental construction. Labor, sampling, sampling equipment and material required for uniformity tests of the concrete mixture shall be furnished by the contractor. The engineer will furnish required testing equipment including scales, cubic measure and air meter. The tests will be performed by the engineer, or by the contractor with approval by the engineer. No direct payment will be made for the labor, equipment, material or testing. After operational procedures of batching and mixing are thus established, no changes in procedure will be permitted without re-establishing procedures by uniformity tests.

501.5.4.1 Measurement of mixing time shall start at the time all the solid material is in the drum and shall end at the beginning of the next sequential operation. The batch shall be so charged into the mixer that some water enters in advance of the cement and aggregate and all water is in the drum by the end of the first one-fourth of the specified mixing time. Mixer performance

tests shall be repeated whenever the appearance of the concrete or the coarse aggregate content of samples selected, in accordance with ASTM C 94, as modified above indicates that adequate mixing is not being accomplished.

501.5.5 Truck mixed concrete shall be mixed at the proportioning plant and the mixer shall operate at agitating speed while in transit. However, truck mixed concrete may be mixed at the point of delivery provided the cement, or cement and mixing water, are added at that point. Mixing of truck mixed concrete shall begin immediately after the introduction of the mixing water to the cement and aggregates, or the introduction of the cement to the aggregate.

501.5.6 A truck mixer shall consist of a watertight revolving drum suitably mounted and fitted with adequate blades, and equipped with a device for determining the number of mixing revolutions. Truck mixers shall produce a thoroughly mixed and uniform mass of concrete, and shall discharge the concrete without segregation. A truck agitator shall consist of a watertight revolving drum or a watertight container suitably mounted and fitted with adequate revolving blades. Truck agitators shall transport and discharge the concrete without segregation. Mixers and agitators shall be cleaned of accumulations of hardened concrete or mortar.

501.5.7 Except as hereinafter permitted, each truck mixer shall have permanently attached to it a metal rating plate issued by and in accordance with the capacity requirements of the Truck Mixer Manufacturers Bureau, as approved by NRMCA, on which is stated its maximum capacity in terms of volume of mixed concrete for the various uses to which the equipment is applicable. It shall also have attached a manufacturer's data plate which shall state the actual capacity as an agitator, the maximum and minimum mixing and agitating speeds and any other data desired by the manufacturer. If truck mixers are used for mixing or agitating, the volume of concrete in each batch shall not exceed the maximum capacity shown on the metal rating plate issued by the Truck Mixer Manufacturers Bureau, as approved by NRMCA, except that if a lower capacity for agitating is shown on the manufacturer's data plate, that lower capacity shall govern. If the equipment does not have attached such a rating plate, the batch volume when the equipment is used as a mixer and as an agitator, shall not exceed 57.5 percent and 80.0 percent of the gross interior volume, respectively. The minimum batch size for truck mixers shall be one cubic yard (cubic meter). The right is reserved to reduce the batch size, or reject use of any truck mixer which does not produce concrete uniform in color, appearance and distribution of material throughout the mass. A quantity of concrete which results in axle and gross loads in excess of statutory limits will not be permitted.

501.5.8 Truck mixers and agitators shall be operated at the speed of rotation designated by the manufacturer of the equipment, provided such speeds are within the following limits. Mixing speed for the revolving drum type of mixer shall be not less than 6 nor more than 18 revolutions of the drum per minute. Agitating speed for both the revolving drum mixers and revolving blade type agitators shall be not less than 2 nor more than 6 revolutions per minute of the drum or of the mixing blades. Truck mixed concrete shall initially be mixed not less than 70 nor more than 100 revolutions of the drum at mixing speed after all of the ingredients, including water, are in the mixer, except that when the batch volume does not exceed 57.5 percent of the gross volume of the drum or 91 percent of the rated maximum capacity, the number of revolutions required for mixing shall not be less than 50 nor more than 100. When a truck mixer or truck agitator is used for transporting concrete that has been completely mixed, agitation of the concrete shall continue during transportation at the speed designated by the manufacturer of the equipment as agitating speed.

501.5.8.1 Water may be added to the mixture not more than two times after initial mixing is completed. Each time water is added, the drum shall be turned an additional 30 revolutions or more if necessary, at mixing speed, until uniform mixing is accomplished. All water added will be included in determining the effective water in the mixture.

501.5.9 Water measuring equipment at the plant or central mixer shall be in accordance with [Sec 501.3.3](#). If the truck mixer is not equipped with a tank and an automatic water measuring device, a calibrated tank or a meter shall be installed on the truck or at the job site for measuring additional water used to obtain satisfactory workability of dry batches. Each increment of water used shall be measured within a tolerance of one percent of the total effective water required for the batch. Water used to wash the drum of the mixer shall not be used as mixing water.

501.5.10 Central or truck mixed concrete shall be delivered to the site of the work and discharge shall be completed within 60 minutes for concrete used for bridge deck surfaces, and within 90 minutes for all other concrete, after the beginning of mixing operations. In hot weather or under conditions contributing to quick stiffening of the concrete, the time shall be reduced as approved by the engineer. Concrete shall be discharged without delay and the time required between the start and completion of discharge shall not exceed 15 minutes for bridge deck surfaces. Discharge time for other concrete pours shall not exceed 15 minutes, except that in the case of small pours, the discharge time may be extended as necessary to provide for proper placing and inspection procedures provided the total mixing, delivery and discharge time does not exceed that specified.

501.5.11 Consideration will be given to permitting the use of non-agitating equipment for the transportation of central mixed concrete, but approval of this procedure, except as qualified in accordance with [Sec 502.3.2](#) for use in portland cement concrete pavement, may be granted only when the quantity of concrete is small, the length of haul short and its use does not require high structural strength for satisfactory performance. The discharge of concrete, for other than pavement, transported in non-agitating equipment shall be completed within 45 minutes after introduction of the mixing water to the cement and aggregates. When hauling heated concrete, or under other conditions contributing to quick stiffening of the concrete, the time shall be reduced as approved by the engineer.

501.5.12 During the time that concrete is being discharged for pours requiring more than one load of concrete, facilities shall be provided to permit constant communication between the site where the concrete is being placed and the proportioning plant.

501.5.13 Inspection. Proper facilities shall be provided for the engineer to inspect ingredients and processes used in the manufacture and delivery of the concrete. A Type 1 Field Laboratory meeting in accordance with [Sec 601](#), shall be provided at the proportioning plant. No direct payment will be made for providing the laboratory. Facilities for obtaining representative samples of each fraction of aggregate, cement and each admixture just prior to incorporation into the mix shall be provided by the producer. Aggregate samples may be taken either by sampling the flowing aggregate stream or by belt sampling. The producer shall furnish the necessary equipment and personnel necessary to assist the engineer in obtaining a representative sample.

501.5.14 Delivery Ticket. The manufacturer of truck mixed concrete, and of central mixed concrete for use in structures, shall furnish to the engineer with each truck load of concrete before unloading at the site, a delivery ticket on which is shown information concerning the concrete as follows:

- (a) Name of concrete plant.
- (b) Serial number of ticket.
- (c) Date and truck number.

- (d) Name of contractor.
- (e) Specific project, route and county designation.
- (f) Specific class of concrete.
- (g) Quantity of concrete in cubic yards (cubic meters).
- (h) Time when batch was loaded, or of first mixing of cement and aggregates.

501.6 Volumetric Batched and Continuous Mixed Concrete. Upon written request by the contractor, the engineer may approve the use of concrete proportioned by volume. If concrete is proportioned by volume, the requirements of [Sec 501](#) with the following modifications shall apply.

501.6.1 Volume proportioning devices, such as counters, calibrated gate openings or flow meters, shall be available for controlling and determining the quantities of the ingredients discharged. In operation, the entire measuring and dispensing mechanism shall produce the specified proportions of each ingredient.

501.6.2 All indicating devices that affect the accuracy of proportioning and mixing of concrete shall be in full view of and near enough to be read by the operator while concrete is being produced. The operator shall have convenient access to all controls.

501.6.3 The proportioning devices shall be calibrated by the contractor in the presence of and subject to the approval of the engineer. Calibration of the cement and aggregate proportioning devices shall be accomplished by weighing (determining the mass of) each component. Calibration of the admixture and water proportioning devices shall be accomplished by weight (mass) or volume. Tolerances in proportioning the individual components are as follows:

Item	Tolerance
Cement, Weight (Mass) percent	0 to +4
Fine Aggregate, Weight (Mass) percent	±2
Coarse Aggregate, Weight (Mass) percent	±2
Admixtures, Weight (Mass) or Volume percent	±3
Water, Weight (Mass) or Volume Percent	±1

501.6.4 Verification of the proportioning devices may be required any time deemed necessary by the engineer. Verification shall be accomplished by the following procedure:

With the cement meter set on zero and all other controls set for the designated mix, the activated mixer shall discharge mixed material into a 1/4 cubic yard (0.25 m³) container measuring 36 x 36 x 9 inches (1000 x 1000 x 250 mm). When the container is level-struck full, making provision for settling the material into all corners, the cement meter must show a discharge equal to the design proportion of cement for 1/4 cubic yard (0.25 m³). A tolerance of ±1/8 inch (±3 mm) from the top of the container will be permitted. If correct yield is not obtained, the proportioning devices shall be adjusted to obtain the design mix or the proportioning devices shall be recalibrated as directed by the engineer.

501.6.5 The rate of water supplied shall be measured by a calibrated flow meter coordinated with the cement and aggregate feeding mechanism, and with the mixer. The rate shall be adjustable in order to control slump at the desired level.

501.6.6 Liquid admixtures shall be dispensed through a controlled flow meter. A positive means to observe the continuous flow of material shall be provided. If an admixture requires diluting, it shall be diluted and thoroughly mixed prior to introducing it into the dispenser. When admixtures are diluted, the ratio of dilution and the mixing shall be approved by and performed in the presence of the engineer.

501.6.7 Mixing. The concrete mixer shall be approved by the engineer and shall be an auger-type continuous mixer used in conjunction with volumetric proportioning. The mixer shall produce concrete, uniform in color and appearance, with homogeneous distribution of the material throughout the mixture. Mixing time necessary to produce uniform concrete shall be established by the contractor and shall comply with other requirements of these specifications. Only equipment found acceptable in every respect and capable of producing uniform results will be permitted.

501.6.7.1 The continuous mixer shall be capable of carrying sufficient unmixed dry bulk cement, fine aggregate, coarse aggregate, admixtures and water, in separate compartments, to produce not less than 6 cubic yards (4.5 m³) of concrete at the job site. Each batching or mixing unit, or both, shall carry in a prominent place a metal plate or plates on which are plainly marked the gross volume of the unit in terms of mixed concrete, discharge speed and the weight-calibrated constant of the machine in terms of a revolution counter or other output indicator.

501.6.7.2 The continuous mixer shall be capable of positive measurement of cement being introduced into the mix. A recording meter visible to the operator and equipped with a ticket printout shall indicate this quantity.

501.6.7.3 The continuous mixer shall provide positive control of the flow of water and admixtures into the mixing chamber. Water flow shall be indicated by a flow meter and be readily adjustable to provide for minor variations in aggregate moisture. The mixer shall be capable of continuously circulating or mechanically agitating the admixtures.

501.6.7.4 The continuous mixer shall have a one-inch (25.0 mm) maximum size scalping screen over the fine aggregate bin to screen out mud balls, conglomerate lumps or any other contaminant material which could interrupt the flow of fine aggregate during proportioning.

501.6.7.5 The continuous mixer shall be capable of being calibrated to automatically proportion and blend all components on a continuous or intermittent basis as required and shall discharge mixed material through a conventional chute.

501.6.8 Storage facilities for all material shall be designed to permit the engineer to make necessary inspections prior to the batching operations. The facilities shall also permit identification of approved material at all times and shall be designed to avoid any mixing with, or contaminating by, unapproved material. Coarse and fine aggregates shall be furnished and handled so that variations in the moisture content affecting the uniform consistency of the concrete will be avoided.

501.7 High Early Strength Concrete. The condition under which high early strength concrete may be used shall either meet the written approval of, or be approved by, the engineer. If Type III, high early strength cement is used, the concrete shall be proportioned in accordance with [Sec 501.2](#) for the various classes of concrete. If Type I portland cement is used to obtain high early strength concrete, the proportions will be approved by the engineer.

501.8 Air-Entrained Concrete. Air content for all classifications of concrete, excluding Class X concrete, shall be determined in accordance with AASHTO T 152, except that a mallet weighing

approximately 0.5 pounds (with a mass determination of 0.23 kg) may be used. Air-entrained concrete shall be used for the construction of the following items.

(a) All retaining walls and all bridge units, except culvert type structures and seal courses.

(b) Concrete median barriers.

(c) All piles (not required for cast-in-place concrete piles).

(d) Concrete pavement.

(e) Approach slab and paved approach.

(f) Concrete median and median strip.

(g) Sidewalk and steps.

(h) Curb, gutter, curb and gutter and surface drain basins and drains.

(i) Concrete pedestals for signs, signals and lighting.

At the contractor's option, all other concrete except seal concrete may be air-entrained but only in accordance with the requirements of these specifications.

501.8.1 If air-entrained concrete is used, the designated quantity of air by volume shall be 7.0 percent with an operating tolerance of 1 1/2 percentage points. For concrete pavement, the specified air content applies to the measurements taken behind the paver or to measurements taken in front of the paver minus the established air loss through the paver. There shall be no intentional deviation from the designated air content. An occasional deviation in air content exceeding the operating tolerance may be permitted if, in the judgment of the engineer, the deviation is such that it will not seriously affect the serviceability of the concrete.

501.8.2 To avoid wide fluctuations in air content, the contractor shall maintain close control over uniformity of cement, aggregates, consistency of the concrete, operation of proportioning and mixing equipment and mixing time. Air entrainment shall be obtained by use of an approved air-entraining admixture added in the quantity required to obtain the designated air content. It shall be the contractor's responsibility to determine and use the quantity of admixture necessary to obtain the designated air content within the permitted operating tolerance.

501.8.3 Air-entraining admixtures shall be added to the concrete during the process of mixing. The admixture shall be of such volume and strength that it can be accurately measured and dispensed by means of an approved mechanical dispenser which will gradually discharge the required quantity of material into the stream of mixing water. The entire quantity of air-entraining admixture shall be fully discharged before all of the mixing water has entered the drum of the mixer. The device shall be so arranged that the flow of air-entraining admixture will be automatically stopped when the required quantity has been delivered. The dispenser shall be so constructed that it can be accurately calibrated at various settings and shall be provided with means by which the discharge can be readily diverted from the stream of mixing water to a container for measurement. The dispenser shall consistently deliver the required quantity of admixture within a tolerance of plus or minus 3 percent.

501.9 Concrete Admixtures for Retarding Set. If specified in the contract, an approved retarding admixture shall be provided and incorporated into the concrete. If not specified in the

contract, the use of an approved retarding admixture may be permitted upon written request by the contractor. Approval for the use of any retarding admixture will be contingent upon satisfactory performance and permission for its use may be withdrawn at any time satisfactory results are not obtained. The use of a retarding admixture for extending the delivery or discharge time of the concrete, or for modifying temperature requirements for placement, will not be approved. Retarding admixture shall be added in accordance with [Sec 501.8.3](#) by means of a dispenser conforming to the requirements of that section. If both retarding and air-entraining admixtures are used, the sequence and rate of discharge of both materials shall be as approved by the engineer. No direct payment will be made for furnishing the retarding admixture or incorporating it into the mixture.

501.10 Water-Reducing Admixtures. At the option of the contractor, Type A water-reducing admixtures may be used in any concrete. High range water-reducing admixtures may be used when specified or with approval of Project Operations.

501.11 Trial Batches. Prior to placement of any concrete in the work, the contractor may be required to prepare trial batches of concrete for tests. The mixing equipment, mixing time, material, proportions, slump and batch size shall be the same as those to be used during the construction. The batches shall be agitated in such manner to simulate the proposed time of haul and discharge. The volume of all concrete prepared for trial batches which are not used in the work will be determined from the summation of the absolute volumes of all ingredients, and the volume of entrained air when used. Payment will be made at 50 percent of the contract unit price for the class of concrete for which the trial batches were prepared.

501.12 Calcium Chloride. The use of calcium chloride or other approved accelerating admixtures in concrete mixtures will not be permitted, except in concrete used for pavement repair, in accordance with [Sec 613](#).

501.13 Fly Ash and Ground Granulated Blast Furnace Slag (GGBFS) in Concrete. The contractor may use fly ash or GGBFS in the production of concrete in accordance with these specifications. Fly ash and GGBFS shall not be intermixed.

501.13.1 Approved Class C or F fly ash may be used to replace a maximum of 15 percent of Type I or II cement and a maximum of 10 percent of Type IP or I(PM) cement, only when made with a natural pozzolan, on a pound for pound (kilogram for kilogram) basis in all concrete except concrete designed for high early strength. Approved GGBFS may be used to replace a maximum of 25 percent of Type I or II cement on a pound for pound (kilogram for kilogram) basis in all concrete except concrete designed for high early strength.

501.13.1.1 Fly ash shall not be used as a replacement for Type III, IP, I(PM), IS or I(SM) cement with the following exception. When the Type IP or I(PM) cement is made with a natural pozzolan and not fly ash, fly ash may be used as a replacement as limited herein.

501.13.1.2 Changes in class or source of fly ash or source of GGBFS used in concrete structures will be permitted only with the written approval of the engineer. Only fly ash or GGBFS resulting in concrete of the same color shall be used in any individual unit of the structure.

501.13.1.3 Fly ash or GGBFS, Type IS or I(SM) cement, or Type IP or I(PM) cement made with fly ash pozzolan shall not be used in pavement concrete placed between November 1 and April 1. These date restrictions do not apply to Type IP or I(PM) cement made with a natural pozzolan.

501.13.2 All proportioning, air-entraining, slump, maximum mixing water requirements, mixing, sampling, measurement of material, transporting of concrete and all material shall be in accordance with [Sec 501](#).

501.13.3 When fly ash or GGBFS is used, an adjustment in design mix proportions will be required to correct the volume yield of mixture. Approval shall be obtained from the engineer prior to any change in mix design or proportions.

501.13.4 Maximum mixing water shall be based on total cementitious material. Ninety-four pounds (42.6 kg) of cementitious material will be considered a sack or bag. The quantity of mixing water in the concrete shall be considered the net quantity after proper allowance has been made for absorption by the aggregates.

501.13.5 Fly ash or GGBFS shall be stored in separate enclosed storage silos during batching operations.

501.13.6 Fly ash or GGBFS shall be measured in the same manner and with the same accuracy as cement. (The mass determination of) Fly ash or GGBFS may be weighed (determined) separately on the same scale as cement provided the scale increments are such that the specified weighing (mass determination) accuracy can be maintained. If, however, the (mass of) fly ash or GGBFS is weighed (determined) together with the cement, the (mass of) cement shall be weighed (determined) first and the accuracy shall apply to the combined weight (mass).

501.13.7 Fly ash or GGBFS shall be considered as cement when measuring mixing time.

501.13.8 When a commercial mixture of concrete is allowed and fly ash or GGBFS is used, the contractor shall notify the engineer of the class, source and quantity of fly ash proposed or the source and quantity of GGBFS proposed, in accordance with [Sec 501](#). The fly ash or GGBFS shall be from an approved source. The quantity of fly ash shall not exceed 15 percent and the quantity of GGBFS shall not exceed 25 percent, by weight (mass), replacement of the cement.

501.14 Commercial Mixture. If specified in the contract that an approved commercial mixture of concrete may be used, the contractor shall notify the engineer in writing, setting out for approval the source and proportions of the mixture proposed to be furnished. The statement shall include the following:

- (a) The types and sources of aggregates.
- (b) Type and source of cement and other cementitious material.
- (c) Scale weights (masses) of each aggregate proposed as pounds per cubic yard (kilograms per cubic meter) of concrete.
- (d) Quantity of water proposed as pounds or gallons per cubic yard (kilograms or liters per cubic meter) of concrete.
- (e) Quantity of cement proposed as sacks per cubic yard (cubic meter) of concrete. If the cement is to be measured by the sack, the weight (mass) per sack shall be shown.

The concrete shall contain not less than 517 pounds (305 kg) of cement per cubic yard (cubic meter). The plant shall be in accordance with [Sec 501](#), or as approved by the engineer. The concrete will be subject to acceptance or rejection by visual inspection at the job site.

501.14.1 The supplier shall furnish a certification with the first truck load of each day's production of concrete certifying that the material and mix proportions used are in conformance with the approved mixture. Upon completion of the work, plant certification shall be furnished by the supplier for the total quantity delivered.

501.14.2 Concrete meeting the material and proportioning requirements for Class B concrete will be acceptable as an approved commercial mixture and may be certified to as such.